

CLIMATIC CONDITIONS IN THE LOUISIANA PURCHASE AS FOUND BY LEWIS AND CLARK IN 1804 AND 1805¹

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At sunrise 125 years ago to-day (December 27, 1929) the only thermometer of record in that vast stretch of country from the middle Missouri Valley to the Pacific Northwest read -4° F. The prized instrument was included in the equipment of Capt. Meriwether Lewis, in charge of a party of 43 men, who were on a journey of exploration, afterwards known as the Lewis and Clark expedition. Starting in Illinois opposite the mouth of the Missouri River on May 14, 1804, the expedition disbanded at St. Louis, Mo., after 2 years 4 months and 9 days of varied experiences and hardships, yet with an outstanding record of scientific achievement. The temperature reading referred to on December 27, 1804, was made at Fort Mandan, N. Dak., where America's pioneer meteorologists were in winter quarters not far from the present location of Bismarck.

It is a striking coincidence that the given name of the first official weather observer to traverse the United States from the Atlantic to the Pacific Oceans via the Ohio, Mississippi, Missouri, and Columbia Rivers should be Meriwether. The euphony of the appellation suggests that the pathfinders of our trans-Missouri domain always encountered fair sailing over the "boils" and "sawyers" of the turbulent Missouri River, which, nevertheless was far from true, as the meteorological register kept on that famous voyage shows. The weather diary kept by the explorers, Capts. Meriwether Lewis and William Clark themselves personally is now in the possession of the American Philosophical Society, Philadelphia, Pa. The daily rise and fall of the principal rivers was noted as carefully as the thermometer and the state of weather.

The original register was kept by Captain Lewis in a book that he had previously used while paymaster in the Army in 1800, and in which he entered his weather diary from January, 1804, to April, 1805. Exceptional care must have been exercised to safeguard the records over a hazardous journey estimated by the explorers to have been 7,689 miles, as shown by the following letter from Librarian Laura E. Hanson, of the American Philosophical Society, dated October 29, 1929: "The original manuscript journals of the Lewis and Clark expedition are in the possession of this society and these journals contain the weather diary kept by the explorers. These are in excellent condition and very easily read."

President Thomas Jefferson, in a secret message to Congress in 1803 requesting \$2,500 to explore the western country that made the records possible, said "that the Missouri River traverses a moderate climate, offering, according to the best accounts, a continued navigation from its source and possible with a single portage from the western ocean." Two thousand five hundred dollars seems a trivial sum for such an undertaking to-day; but it must be remembered that Iowa farm land was purchased by Thomas Jefferson, who was making the request, for between 2 and 3 cents an acre, and a private soldier in the United States Army in 1803 was paid \$5 a month for his services. The expedition, while being scientific, was also strictly military.

Keeping of weather records was an interesting diversion from statecraft for the founders of our Government, and Thomas Jefferson was no exception, as the instructions written by him to Captain Lewis on June 20, 1803, proves. He instructed him to record the "Climate as

characterized by the thermometer, by the proportion of rainy, cloudy, and clear days, by lightning, hail, snow, ice, by the access and recess of frost, by the winds prevailing at different seasons, the dates at which particular plants put forth or lose their flowers or leaf, and times of appearances of particular birds, reptiles, or insects."

These instructions were carried out to the letter where it was humanly possible, and the records will bear me out in that statement. A few examples follow: Lewis and Clark's measurement of the distance from the mouth of the Missouri River to Sioux City, Iowa, was 850 miles, or 43 miles more than the United States engineers' measurement 100 years afterwards over a channel that is known to change abruptly from year to year.

Point of observation No. 33, in their astronomical observations 4 miles above the present location of Sioux City, taken on a large sand bar, was given as latitude $42^{\circ} 28' 29''$ and the reading as used at present is $42^{\circ} 29'$, or a difference of $31''$.

The lone thermometer that started the journey was carefully tested on January 1, 1804, when records were begun, using water and snow mixed to determine the freezing point and boiling water to test the boiling point on the instrument.

Precision must have been used in noting the time, as is well shown in the observation of a total lunar eclipse on the night of January 15, 1805, at Fort Mandan, N. Dak., from 12 midnight until 3 a. m. In a letter, dated October 3, 1929, Mr. James Robertson, director of the American Ephemeris, has the following to say with reference to this eclipse: "From the British Nautical Almanac for 1805 (confirmed by the French *Connaissance des Temps*) we obtain, by applying equation of time and longitude, the following local mean times at Mandan, N. Dak., for the circumstances of the total lunar eclipse of 15 January:

Eclipse begins.....	12:08 a. m.
Totality begins.....	1:06 a. m.
Middle of eclipse.....	1:56 a. m.
Totality ends.....	2:45 a. m.
Eclipse ends.....	3:43 a. m.

"For apparent local times, subtract 10 minutes. For mountain standard time, subtract 16 minutes." From the foregoing information, the eclipse should have first been noted at Fort Mandan at 11:58 p. m., January 14, 1805, or within two minutes of the time mentioned as first observed, which is unusually close for amateur astronomers out of touch of civilization.

The first mention of frost in the diary was on October 5, 1804, near Mobridge, S. Dak., or 19 days later than the average first frost in that locality. The first killing frost was observed near the mouth of the Cannonball River in North Dakota on October 18, 1804, when the thermometer at sunrise registered 30° . For that section it was about seven days later than the average date for the first killing frost.

Snow was first seen on October 21, 1804, when it fell to the depth of one-half inch near Bismarck, N. Dak., where usually the first snowfall of that amount is November 6.

On November 13, 1804, at 10:30 p. m., drift ice began to run in the Missouri River at Fort Mandan, and on November 30 the river was frozen over so that it could be crossed on the ice, which was three days later than the average closing in that locality. Great herds of buffalo crossed the Missouri River near the fort 10 days after it

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closed. (As many as 20,000 buffaloes were seen at one time by the explorers.) The ice gave way in the river about 3 p. m. March 26, 1805, and came down in immense sheets, giving a closed season for navigation at Fort Mandan during the winter of 1804-5 of 116 days, or 9 days less than the Bismarck (N. Dak.) average.

The sergeant of the guard awakened the party to observe "northern lights" on the evening of November 5, 1804.

The annual "big flight" of wild geese, ducks, and brants started on November 9, 1804, which is not far from the average date. It is interesting to note that a mallard duck was always referred to in their journals as a duckanmallard. The wild geese usually nested in the top of broken trees, sometimes in the fork of a large tree, but almost invariably from 15 to 20 feet or upward high.

The first zero temperature at Fort Mandan, N. Dak., was recorded on December 7, 1804, in connection with a severe cold wave that lasted until the 19th. The average date for the first zero temperature at Bismarck is November 25 or 12 days earlier than in the winter of 1804-5 at Fort Mandan.

On April 1, 1805, the first thunder of the season was heard. It attended the first shower of rain witnessed since September 15, 1804. Captain Lewis noted that he had observed that all thunderclouds in the western part of the continent proceed from the westerly quarter, as they do in the Atlantic States. Another noteworthy conclusion of the earliest of field workers in the realm of the new science of meteorology while quartered on the Pacific coast, and written on January 31, 1806, says: "The winds from the land brings us cold and clear weather while those obliquely along either coast or off the ocean brings us warm, damp, cloudy, and rainy weather. The hardest winds are always from the southwest." This statement regarding wind and weather conditions on the north Pacific coast is substantially in accord with the facts, according to E. H. Bowie, district forecaster, Weather Bureau office, San Francisco, Calif. Thomas R. Reed, in *Rain-bearing winds of the Far Western States*, MONTHLY WEATHER REVIEW, May, 1927, says, "Given a reasonably free exposure, the rain-bearing surface winds are preponderantly from southerly quarters" and "Infrequency of precipitation with east winds in the far West is a phenomenon of special note."

A graphical account of a hailstorm encountered at the present site of Great Falls, Mont., illustrates the severe privations which the elements meted out to the party on June 27, 1805, when the following entry was made: "At 1 p. m. a black cloud which arose in the southwest came on, accompanied with a high wind and violent thunder and lightning; a great quantity of hail also fell during this storm, which lasted about two hours and a half. The hail, which was generally about the size of pigeon eggs and not unlike them in form, covered the ground to one inch and a half. For about 20 minutes during this storm hail fell of an enormous size, driven with violence almost incredible; when they struck the ground they would rebound to the height of 10 to 12 feet and pass 20 or 30 before they touched again. During this immense storm I (Captain Clark) was with the greater part of the men on the portage. The men saved themselves, some by getting under a canoe, others by putting sundry articles on their heads. Two were knocked down and several with their legs and thighs much bruised. Captain Lewis weighed one of those hailstones which weighed 3 ounces and measured 7 inches in circumference; they were generally round and perfectly solid. I am convinced if one of those had struck a man

on the naked head it certainly would have fractured his skull." The word "blizzard" had not been coined at that time to describe a severe snowstorm, and consequently the expression does not appear anywhere in their journals. As a matter of fact, the term "blizzard," did not come into general use until about 1870. Previously, however, in the fifties and sixties, a Dakota blizzard was called "pouderie" among the French settlers, meaning powder mill—the force of which will be appreciated by anyone who has had a blizzard burst upon him.

Their phenological observations were recorded somewhat on the order of those now published in the Quarterly Journal of the Royal Meteorological Society, but, of course, were less comprehensive. Many new species of both animals and plants then unknown to the world were discovered.

Zoological notes were kept and anything of peculiar interest was noted. For instance, we are often called on to explain various unbelievable occurrences in connection with tornadoes. I recall a discussion at the Kansas City meeting of the American Meteorological Society in December, 1925, as to why fowls lost their feathers in such storms. The observations of Lewis and Clark in their description of the pelican answers the question in part, at least. They say "The thigh is covered with feathers within a quarter of an inch of the knee. It has a curious frothy substance which seems to divide its feathers from the flesh of the body and seems to be composed of globules of air and perfectly embraces the part of the feather which extends through the skin." Nature has made it easy to remove the feathers of a fowl, and the sudden change in air pressure with the passage of a tornado acts to cause an outward pressure from the base of the feather that could very easily account for the "picking" of a chicken or duck that may happen in the path.

Although we have recited only a few items that should interest members of the Meteorological Society from the original journals and weather diary of the Lewis and Clark expedition they show the unquestioned loyalty of the members of that party to the leaders of the expedition and how carefully and conscientiously Thomas Jefferson's instructions to Captains Meriwether Lewis were carried out. In fact, the records themselves are worthy of emulation by modern weather observers.

We can not refrain from giving two or three notations relative to the thermometer that would have been the first to cross the United States if fate had served it more kindly. On July 22, 1805, while located near Helena, Mont., Captain Lewis wrote: "I placed my thermometer in a good shade as was my custom, about 4 p. m., and after dinner set out without it. I sent Sergeant Ordway back for it. He found it and brought it on." On September 6, 1805, this notation was made, "Thermometer broke by the box striking against a tree in the Rocky Mountains. No further readings after September 5, 1805." And on January 3, 1806, while on the Pacific coast, the last reference is found when the leader of the party wrote: "The loss of my thermometer I most sincerely regret. I am confident that the climate here is much warmer than in the same parallel of latitude on the Atlantic Ocean, though how many degrees is now out of my power to determine."

Although the thermometer did not live to give an early temperature record of the north Pacific coast, happily it served a valuable purpose during the winter of 1804-5 in the center of the continent at Fort Mandan, N. Dak. A comparison of temperature records as kept by the explorers 125 years ago and now shows no radical diver-

sions, although we must admit that the explorers chose a cold winter to visit North Dakota. The records from the Bismarck (N. Dak.) station for comparative purposes have been furnished through the courtesy of Mr. Orris W. Roberts, official in charge of the Weather Bureau office at that station. Captain Lewis or Captain Clark read their only thermometer themselves personally at sunrise and 4 p. m. each day and entered the readings in the meteorological register.

A computation of the mean temperature from November to March, inclusive, at Bismarck from November, 1924, to March, 1929, discloses that the monthly mean temperature at that place averaged 0.7° lower than the mean of the temperature at sunrise and 4 p. m. Deducting that amount from the mean monthly temperature for the winter months of 1804-5 as shown in the Lewis and Clark record gives a fair comparison with modern Weather Bureau records at Bismarck, N. Dak.

Using a -0.7° correction to the mean of the sunrise and 4 p. m. readings during the winter of 1804-5 to reduce the temperature to a monthly mean basis, Lewis and Clark would have obtained the following results at Fort Mandan: December, 1804, 3.1° ; January, 1805, -3.9° ; and February, 1805, 10.5° .

The records show that Lewis and Clark encountered the coldest December and January combined of record in the vicinity of Bismarck, although December, 1879, and December, 1927, were colder than in 1804; and January, 1875, 1887, 1888, and 1916 averaged lower than January, 1805. The minimum temperature at Fort Mandan for December, 1804, was -43° on the 17th, which was 1° lower than the absolute December minimum at Bismarck established on December 20, 1916. November, 1804, was 4.2° warmer than the 55-year average at Bismarck, February, 1805, 0.2° warmer, and March, 1805, 3.5° warmer.

A perusal of the interesting initial diary of the Missouri Valley does not disclose, however, that the climate 125 years ago in the home of the tornado and the blizzard differed much from what it is to-day. The original engineer of the Great Plains, the American bison, who followed the lay of the land and the run of the water, thrived in vast herds under similar climatic conditions and less protection than the horse, cow, and sheep do to-day.

Delving into old records and getting the viewpoint of past generations holds a fascination and it has amply repaid me for the reading of the Original Journals of the Lewis and Clark Expedition, printed from the original manuscript and now in the possession of the American Philosophical Society. Most of the subject matter of this paper was obtained from that source. One of the happy rewards for a person who has been studying stream flow in the Missouri River for years was the discovery of what is probably the origin of the fallacy that the annual

rise in the middle and lower Missouri River, commonly known as the June rise, is due to the melting snows in the northern Rocky Mountains.

The Lewis and Clark expedition were detained about seven weeks in the northern Rockies on the return journey in consequence of the snow, and the experiences encountered lead Captain Lewis to write, on June 2, 1806: "I have no doubt but that the melting of the mountain snow in the beginning of June is what causes the annual inundation of the lower portion of the Missouri River from the first to the middle of July." This mistaken idea persists in the minds of a large percentage of the dwellers of the Missouri Valley. Its origin may have been in the statement just read, although the explorers may have been misled by the Indians, who are in many cases not interested enough in rivers even to give them a name. As an example, the Columbia River has no name among any of the tribes living on it. The cause of high water during June and July in the middle Missouri River was shown by Charles D. Reed in his article on "Floods of the upper Missouri River," MONTHLY WEATHER REVIEW, June, 1911, to have been due to heavy rainfall, with the mountain snowfall exerting a negligible influence.

Speaking of rivers, it is worth while to recall that while Captain Lewis was descending the Ohio on the outward journey he wrote to President Jefferson, from Wheeling, W. Va., on September 8, 1803, as follows: "The River (Ohio) is lower than it has been known by the oldest settlers in this country. On many bars the water in the deepest part does not exceed 6 inches." Again, on October 3, at Cincinnati, Ohio, he remarked, "The water still continues lower in the Ohio than it was ever known."

Lewis and Clark named many rivers of the Northwest. They terminated the name of the Missouri River at Three Forks, Mont., and on July 28, 1805, the following entry appears in their diary: "Both Captain Clark and myself corresponded in opinion with the impropriety of calling either of these streams the Missouri and accordingly agreed to name them after the President of the United States and the Secretaries of Treasury and State, having previously named one river in honor of the Secretaries of War and Navy. In pursuance of this resolution we called the southwest fork, that which we meant to ascend, Jefferson River in honor of that illustrious personage, Thomas Jefferson (the author of our enterprise), the middle fork we called Madison River in honor of James Madison, and the southeast fork we called Gallatin River in honor of Albert Gallatin."

I have endeavored to set out not only weather conditions of interest as found by Lewis and Clark on their great expedition of exploration but other items of public interest as well in this new era of developing what ought to be the longest river in the world, the Missouri—a river with a romantic past and a useful future.

MUD FLOODS IN UTAH

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Numerous rapid and heavy local downpours of rain during the first two weeks in August produced an extraordinary number of washing floods in the mountain sections of Utah, several of them similar to the destructive earth washes of July 10, 1930, between Centerville and Farmington.

The first of these floods, on the afternoon of August 2, flooded an area of approximately a square mile of industrial section in northwestern Salt Lake City with slime,

gravel, and rocks from the steep, smooth mountain side adjacent, and from the caving walls of gravel pits and other excavations. Rivers of mud ran down the streets and roads and over a wide area of improved premises, while in the more concentrated parts of the avalanche great masses of moraine gravel and rocks were transported and deposited into depressions, more especially in the cut through which the State-paved highway passes parallel to the foot of the slope.